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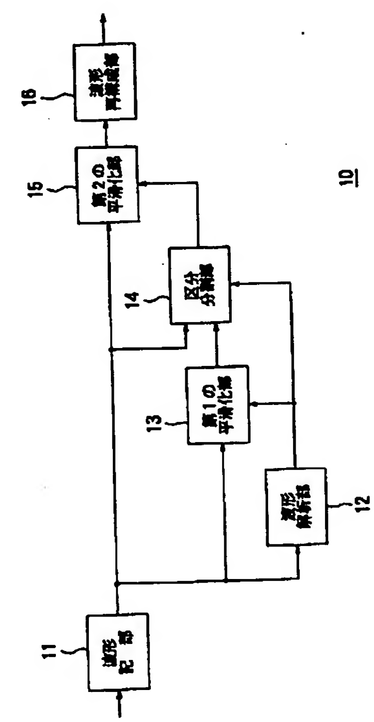
(54)【発明の名称】　信号処理装置および信号処理方法

(57)【要約】
【目的】信号波形データに対する平滑化処理を、適切かつ自動的に行うことのできる信号処理装置を提供する。
【構成】信号処理装置１０に入力された信号波形は波形記憶部１１に記憶される。波形解析部１２で、その信号波形より高周波成分を抽出し、その高周波成分のパワーが所定値以上だった場合には第１の平滑化部１３でその信号波形全体に対して平滑化を行う。区分分割部１４では、前記平滑化が行われなかった場合は原信号波形を対象として、前記平滑化が行われた場合は平滑化が施された信号波形を対象として、その信号波形の変化の状態を解析し、原信号波形を複数の区分に分割する。そして、第２の平滑化部１５で、その各区分ごとに平滑化の処理を行い、波形再構成部１６で、各区分ごとの平滑化された信号波形を統合し、原信号波形を平滑化した信号波形を再構成する。



【特許請求の範囲】

【請求項１】変化の緩急差の大きい時系列波形データについて、周波数分析し、パワーが大きな高周波成分のノイズ成分を除去し、前記変化の緩急に基づいて前記元の時系列波形データを連続的な領域ごとに分割する分割手段と、
前記分割された各領域ごとの時系列波形データを平滑化する平滑化手段と、
前記平滑化された各領域ごとの時系列波形データを、元の時系列波形データに対応させて再構成する波形再構成手段とを有する信号処理装置。

【請求項２】前記平滑化手段は、前記分割された各領域ごとの時系列波形データをスプライン平滑化法により平滑化する請求項１記載の信号処理装置。

【請求項３】前記分割手段は、
前記時系列波形データをフーリエ変換により周波数分析し高周波成分のノイズを検出する解析手段と、
前記検出された高周波成分のパワーが大きいノイズ成分を除去するローパスフィルタ手段と、
前記ノイズ成分が除去された時系列波形データを変化の激しい領域と変化の緩やかな領域とに分割する分割点決定手段とを有する請求項１または２記載の信号処理装置。

【請求項４】変化の緩急差の大きい時系列波形データについて周波数分析し、
前記分析によりパワーが大きな高周波成分のノイズが検出された場合に、該ノイズ成分を除去し、
前記変化の緩急に基づいて前記元の時系列波形データを連続的な領域ごとに分割し、
前記分割された各領域ごとの時系列波形データを平滑化し、
前記平滑化された各領域ごとの時系列波形データを、元の時系列波形データに対応させて再構成する信号処理方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、観測した信号波形のノイズ除去および平滑化を行う信号処理装置および信号処理方法に関する。

【０００２】

【従来の技術】たとえば、電線が断線したり冠水したりして生じた異常・故障を、電線に所定のパルス信号を印加しその反射信号を観測して検査する場合などに、観測した波形データのノイズを除去し平滑化する方法としては、フーリエ解析により高周波ノイズを検出し、所定のフィルタによりその高周波ノイズを除去する方法がしばしば用いられる。しかし、そのような方法は、一般的に波形が鈍りやすく、変換点の位置を維持するには適していない。

【０００３】波形の持つ特徴を温存して平滑化する方法としてはスプライン平滑化手法が適している。しかし、スプライン平滑化においても、ノイズが大きい場合や、変化の激しい箇所が続く場合、あるいは、変化の激しい場所と平坦な場所の差が激しい場合などには、波形の鈍りは避けられなかった。そこで、これまで、波形により種々の観測を行うような、特に波形が重要な場合には、フーリエ変換やスプライン関数などの数学的知識をある程度有している作業者が、パラメータや節点数などを適宜選択しながら、試行錯誤を行ってノイズ除去を行い、適切な平滑化を行うようにしていた。

【０００４】

【発明が解決しようとする課題】しかし、そのようにパラメータを適宜選択しながら試行錯誤により平滑化を行う方法は、たとえば、フーリエ変換などの関数や情報処理上の専門知識をある程度必要とするため、平滑化の方法を理解している作業者しか行えず、誰にでもできるというものではなかった。したがって、誰が使っても適切な平滑結果の得られるシステム、すなわち、測定データを指示しさえすれば、自動的に各手法の選択や試行錯誤を行い、平滑後の波形を出力する波形平滑化装置への要望があった。

【０００５】したがって、本発明の目的は、観測した信号波形データに対するノイズ除去および平滑化の処理を、適切にかつ自動的に行うことのできる信号処理装置を提供することにある。また、本発明の他の目的は、観測した信号波形データに対する平滑化処理を適切に行うことのできる信号処理方法を提供することにある。

【０００６】

【課題を解決するための手段】前記課題を解決するために、波形の変化の状態が均一的であれば、たとえばスプライン平滑化法により適切に平滑化が行えることに着目し、観測された信号波形データの変化の状態が同一的な箇所ごとに、各々適切なパラメータを設定して平滑化を行うようにした。

【０００７】したがって、本発明の信号処理装置は、変化の緩急差の大きい時系列波形データについて、周波数分析し、パワーが大きな高周波成分のノイズ成分を除去し、前記変化の緩急に基づいて前記元の時系列波形データを連続的な領域ごとに分割する分割手段と、前記分割された各領域ごとの時系列波形データを平滑化する平滑化手段と、前記平滑化された各領域ごとの時系列波形データを、元の時系列波形データに対応させて再構成する波形再構成手段とを有する。

【０００８】特定的には、前記平滑化手段は、前記分割された各領域ごとの時系列波形データをスプライン平滑化法により平滑化する。

【０００９】好適には、前記分割手段は、前記時系列波形データをフーリエ変換により周波数分析し高周波成分のノイズを検出する解析手段と、前記検出された高周波成分のパワーが大きいノイズ成分を除去するローパスフ

ィルタ手段と、前記ノイズ成分が除去された時系列波形データを変化の激しい領域と変化の緩やかな領域とに分割する分割点決定手段とを有する。

【００１０】また、本発明の信号処理方法は、変化の緩急差の大きい時系列波形データについて周波数分析し、前記分析によりパワーが大きな高周波成分のノイズが検出された場合に、該ノイズ成分を除去し、前記変化の緩急に基づいて前記元の時系列波形データを連続的な領域ごとに分割し、前記分割された各領域ごとの時系列波形データを平滑化し、前記平滑化された各領域ごとの時系列波形データを、元の時系列波形データに対応させて再構成する。

【００１１】

【作用】本発明の信号処理装置によれば、変化の緩急差の大きい時系列波形データについて、分割手段において周波数分析して高周波ノイズを検出する。その高周波ノイズが大パワーだった時には、さらに前記分割手段においてそのノイズ成分を除去し、そのノイズ成分を除去した波形データを対象として変化の状態が同一的な領域に分割するための分割点を求める。前記高周波ノイズのパワーが大きくなかった時は、元の時系列波形データを対象として前記分割点を求める。そして、その分割点に基づいて、元の時系列波形データを複数の領域に分割する。そして、平滑化手段により各分割された領域ごとに平滑化を行い、波形再構成手段により前記平滑化された各領域ごとの時系列波形データを、元の時系列波形データに対応させて再構成する。

【００１２】また、本発明の信号処理方法によれば、変化の緩急差の大きい時系列波形データを周波数分析して高周波ノイズを検出し、その高周波ノイズが大パワーだった時にはさらにそのノイズ成分を除去し、そのノイズ成分を除去した波形データを対象として変化の状態が同一的な領域に分割するための分割点を求める。前記高周波ノイズのパワーが大きくなかった時は、元の時系列波形データを対象として前記分割点を求める。次に、その分割点に基づいて、元の時系列波形データを複数の領域に分割し、各分割された領域ごとに平滑化を行い、平滑化された各領域ごとの時系列波形データを、元の時系列波形データに対応させて再構成する。

【００１３】

【実施例】本発明の一実施例について図１～図５を参照して説明する。図１は、本発明の信号処理方法を適用した本発明の信号処理装置の一実施例の構成を示すブロック図である。本実施例の信号処理装置１０は、波形記憶部１１、波形解析部１２、第１の平滑化部１３、区分分割部１４、第２の平滑化部１５、および、波形再構成部１６を有する。本実施例の信号処理装置１０は、導電線の故障、たとえば導電線が冠水した場合などに導電線に所定のパルス信号を印加し、その反射信号を観測して導電状態を検査する検査装置に用いられ、その観測した反射信号を平滑化するための信号処理装置である。

【００１４】まず、信号処理装置１０の各部の構成・動作について説明する。波形記憶部１１は、入力された信号波形を記憶する。波形記憶部１１に記憶された原信号波形は、波形解析部１２、第１の平滑化部１３、区分分割部１４、および、第２の平滑化部１５より読み出される。

【００１５】波形解析部１２は、波形記憶部１１に記憶されている原信号波形に大パワーのノイズがあるか否かを調べる。波形解析部１２においては、原信号波形を高速フーリエ変換（ＦＦＴ）し周波数帯域別のパワー分布を求め、所定の高周波数領域に予め定めた所定値以上のパワーが存在するか否かを判定する。前記所定値以上のパワーが存在する場合には、第１の平滑化部１３および区分分割部１４にその旨を示す信号を出力する。

【００１６】第１の平滑化部１３は、原信号波形に大パワーの高周波ノイズがあった場合に、その高周波ノイズの除去を行う。すなわち、波形解析部１２から入力原信号に所定値以上のノイズが存在する旨の信号が入力された場合に、波形記憶部１１に記憶されている原信号波形に対してノイズ除去の処理を行う。このノイズ除去の方法は、ローパスフィルタなどを用いた任意の通常のノイズ除去の方法でよい。また、後述する第２の平滑化部１５で行うスプライン平滑化を行ってもよい。ただし、その際、節点数の上限は、データ点数の５％～１０％の範囲内に設定する。各データ点について求められた平滑値、すなわち平滑化された信号波形は区分分割部１４に出力される。

【００１７】区分分割部１４は、信号波形を、急な変化の続く区分と、緩やかな変化の区分とに分割する。具体的には、信号波形の微分係数を求め、その絶対値の大きいものを抽出し、その分布に基づいて、信号波形の変化の緩やかな箇所（平坦部）と、変化の激しい箇所（変化部）とに分類する。また、特に変化部においては、大きな波形の変化が各区分に１つ含まれるように分割する。

【００１８】なお、区分分割部１４においては、波形解析部１２から入力原信号に所定値以上のノイズが存在する旨の信号が入力された場合には、入力原信号に対して第１の平滑化部１３で平滑化の行われた信号波形を用いて区分分割の処理を行う。また、波形解析部１２から入力される信号により、入力原信号に所定値以上のノイズが存在しない場合には、波形記憶部１１に記憶されている入力原信号を対象として、区分分割の処理を行う。分割された各区分を示すデータは、第２の平滑化部１５に出力される。

【００１９】第２の平滑化部１５は、波形記憶部１１に記憶されている入力原信号を対象として、区分分割部１４により分割された各区分ごとに平滑化の処理を行う。この平滑化は、スプライン関数による平滑化法により行う。以下、この平滑化について説明する。

【００２０】本実施例におけるスプライン関数による平滑化は、スプライン関数の節点を適応的に追加して残差二乗和が与えられた許容値以下となるようなm次のＢスプライン平滑化式を求めることにより行う。すなわち、原信号波形データが、離散点x_1，x_2，・・・，x_nにおいて観測誤差σ_1，σ_2，・・・，σ_nを有する観測値y_1，y_2，・・・，y_nのデータである時、式１に示す残差二乗和$\delta_{nr}{}^2$が許容値$\delta_t{}^2$以下となるように、式２のm次のＢスプライン平滑化式を求め、その平滑化式に基づいて各点の平滑値を求める。

【００２１】

【数１】

$$\delta_{ni}^2=\sum_{i=1}^{n}\frac{1}{\sigma_i^2}\left\{y_i-\bar{S}(xi)\right\}^2 \quad \cdot\cdot\cdot(1)$$

$$\bar{S}(x)=\sum_{j=-m+1}^{ni-1}C_jN_{j,}m+1(x) \quad \cdot\cdot\cdot(2)$$

ただし、nはデータ点数、
$N_{j,m+1}(X)$はＢスプライン、
mはＢスプラインの次数で本実施例では3、
S(X)は$\xi1,\xi2\cdots,\xi nr$を節点列とする
m次のＢスプライン平滑化式、
C_jは係数
である。

【００２２】まず、平滑化を行う区間の両端x_1，x_nを節点ξ_1，ξ_{nr}として、式１に示した残差二乗和$\delta_{nr}{}^2$を最小になるように、式２のスプライン平滑化式の係数c_jを決定する。この残差二乗和$\delta_{nr}{}^2$が式３の条件を満たした場合には、その係数c_jによる式２のスプライン平滑化式を求めるべきm次のＢスプライン平滑化式とする。

【００２３】

【数２】

$$\delta_{nr}{}^2\leqq\delta_t{}^2 \quad \cdot\cdot\cdot(3)$$

ただし、δt^2は許容値である。

【００２４】もし、残差二乗和$\delta_{nr}{}^2$が式３の条件を満たさない場合は、節点列の部分区間［ξ，ξ_{j+1}）における残差二乗部分和を式３により各ｊについて計算し、

【００２５】

【数３】

$$\delta^2(j,n_r)=\sum_{\xi_j\leqq X_i<\xi_{j+1}}\frac{1}{\sigma_i^2}\left\{y_i-\bar{S}(x_i)\right\}^2 \quad \cdot\cdot\cdot(4)$$

【００２６】その中で、式４の値が最大となる区間の中点$\xi=(\xi_j+\xi_{j+1})/2$を新たな節点として節点列に追加する。更新された節点列を、小さい順に並べ替え、それを新たな節点列ξ_1，ξ_2，・・・，ξ_{nr}，ξ_{nr+1}として、式１に示した残差二乗和$\delta_{nr}{}^2$を最小になるように、式２のスプライン平滑化式の係数c_jを決定し、以下同様の処理を繰り返す。なお、節点の個数は予め定めた上限値内で順次増やすものとし、信号処理装置１０の第１の平滑化部１３においては入力波形データのデータ点数の約１０％～約３０％の範囲とする。そして、式２に示すスプライン平滑化式が求まったら、各データ点について平滑値を求める。

【００２７】波形再構成部１６は、第２の平滑化部１５において、各区分ごとに平滑化された信号を前記分割された情報に基づいて適宜合わせ、信号波形を再構成する。

【００２８】次に、信号処理装置１０の動作について図２を参照して説明する。処理をスタートする時点で、信号処理装置１０は、まず、入力された信号波形データを波形記憶部１１に記憶する（ステップＳ０）。次に、波形解析部１２において、入力された信号波形データをフーリエ解析して高周波成分を抽出し、そのパワースペクトルを算出する（ステップＳ１）。その高周波成分のパワーが予め定めた所定値以上だった場合には（ステップＳ２）、波形記憶部１１に記憶されている入力された信号波形データ全体に対して、第１の平滑化部１３において平滑化を行う（ステップＳ３）。

【００２９】そして、ステップＳ２において高周波成分のパワーが所定値以下だった場合には原信号波形データを対象として、高周波成分のパワーが所定値以上だった場合にはステップＳ３で平滑化が施された信号波形データを対象として、区分分割部１４において、信号波形を変化の状態が異なる区間の境界を分割点として抽出する（ステップＳ４）。そして、その分割点に従って、入力された原信号波形データを複数の区分に分割し（ステップＳ５）、第２の平滑化部１５において各区分ごとに平滑化の処理を行う（ステップＳ６）。全区分について平滑化の処理が終了したら（ステップＳ７）、波形再構成部１６において各区分ごとの平滑化された信号波形を統合して波形を再構成し（ステップＳ８）、平滑化した信

号波形を得て処理を終了する（ステップＳ９）。

【００３０】次に、信号処理装置１０により平滑化された信号の例を図３～図５に例示する。図３は、入力信号波形データの例を示す図であり、高周波のノイズがのっている波形を示す図である。このような信号波形データに対して、まず、第１の平滑化部１３において、波形データ全体にのっている高周波ノイズを除去する。その結果の信号波形を図４に示す。

【００３１】この図４に示した信号波形を対象として、その微分係数に基づいて、変化の激しい変化部と、比較的変化の少ない平坦部とに分割すると、図４に示す区分Ｔ１～Ｔ８に分割される。図４において、区分Ｔ１，Ｔ４，Ｔ６，Ｔ８が平坦部であり、区分Ｔ２，Ｔ３，Ｔ５，Ｔ７が変化部である。前述したように、変化部の各区分には信号波形の変化の激しい箇所を１つ含むように分割するため、区分Ｔ２と区分Ｔ３は隣接しているが、別個の区分に分割されている。そして、図４に示した各区分ごとに平滑化を行うことにより、図５に示すような平滑化された信号波形が得られる。

【００３２】以上説明したように、本実施例の信号処理装置１０においては、波形に予め区分分割の処置を施し、その後、各区分ごとにスプライン平滑化を行っている。したがって、各区分の信号波形の状態に合わせて適切に平滑化が行えるため、信号波形全体としても、波形の特徴を損なうことなく、適切な平滑化が行えわれている。また、特に、波形が大きく変化している変化部においても、本実施例のように、各区分に含まれている変化の激しい箇所を１箇所だけにした場合には、相当のパワーのノイズが重畳している場合でも、ゆうこう滑化が可能である。

【００３３】なお、本発明の信号処理装置および信号処理方法は、本実施例に限れるものではなく、種々の改変が可能である。たとえば、本実施例の信号処理装置は、導電線の故障、たとえば導電線が冠水した場合などに導電線に所定のパルス信号を印加し、その反射信号を観測して導電状態を検査する検査装置に用いられ、その観測した反射信号を平滑化するための信号処理装置であった。しかし、これに限られるものではなく、伝搬波形を解析して内部の診断を行うような種々の検査装置などに適用可能である。また、通常の通信波形の平滑化などにも適用可能である。

【００３４】また、平滑化方法としてはスプライン関数を用いて平滑化するものとしたが、これに限られるものではなく、種々の平滑化方法、たとえばウェーブレット変換によるような方法でも何ら差し支えない。

【００３５】また、本発明の信号処理装置の使用形態は種々の形態で使用されてよい。たとえば、観測される信号波形を直接本実施例の信号処理装置に入力し、実時間で信号波形の平滑化を行い、平滑化された信号波形を直ちに出力し後段の処理装置に入力されるような形態でもよく、また、観測した信号波形をレコーダなどに記録しておき、後にまとめて解析するような形態でもよい。さらに、その実施形態は専用のハードウェアにより実施してもよいし、汎用の計算機装置を用いて実施してもよい。

【００３６】

【発明の効果】本発明の信号処理装置を使用することにより、観測した信号波形データに対する平滑化の処理を、適切にかつ自動的に行うことができる。したがって、誰が使っても適切な平滑結果の得られるシステムが提供でき、専門の作業者以外の一般の作業者においても観測した信号波形の処理が可能となる。ひいては、たとえば電線などの検査を行う現場においても、観測した信号波形に基づいて効率よく検査が可能となる。また、本発明の信号処理方法によれば、観測した信号波形データに対する平滑化の処理を、作業者が試行錯誤を繰り返す必要なく、自動的に適切に行うことができる。

【図面の簡単な説明】

【図１】本発明の一実施例の信号処理装置の構成を示すブロック図である。

【図２】本発明の一実施例の信号処理装置の動作を示すフローチャートである。

【図３】本発明の信号処理装置に入力される信号波形データを示す図である。

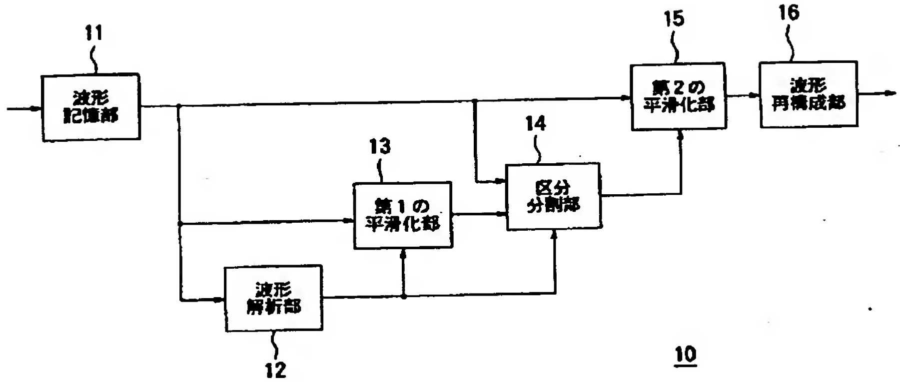
【図４】図３に示した信号波形データに対して高周波ノイズを除去し、区分に分割した状態を示す図である。

【図５】図３に示した信号波形データに対して本発明の信号処理装置により平滑化を施した結果の信号波形データを示す図である。

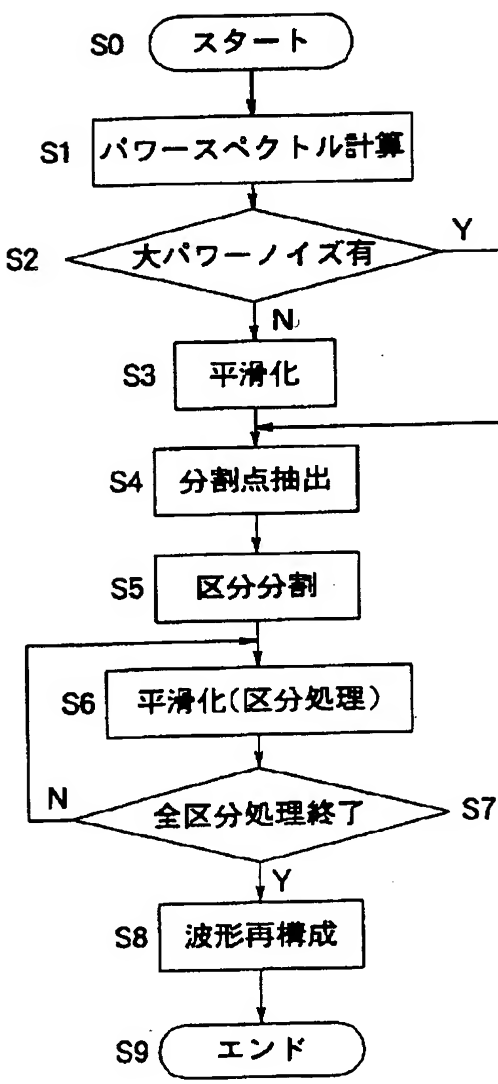
【符号の説明】

１０…信号処理装置
１１…波形記憶部
１２…波形解析部
１３…第１の平滑化部
１４…区分分割部
１５…第２の平滑化部
１６…波形再構成部

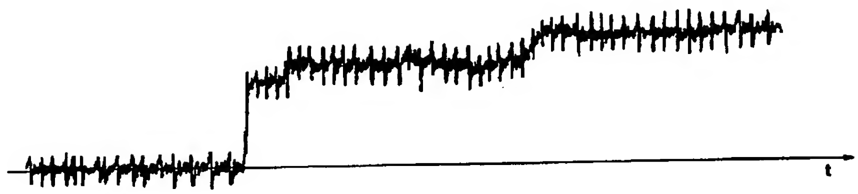
【図1】


11
波形記憶部
12
波形解析部
13
第1の平滑化部
14
区分分割部
15
第2の平滑化部
16
波形再構成部
10

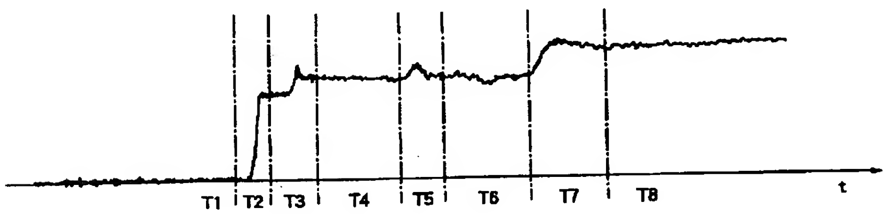
【図2】


S0 スタート
S1 パワースペクトル計算
S2 大パワーノイズ有
Y
N
S3 平滑化
S4 分割点抽出
S5 区分分割
S6 平滑化（区分処理）
N
S7 全区分処理終了
Y
S8 波形再構成
S9 エンド

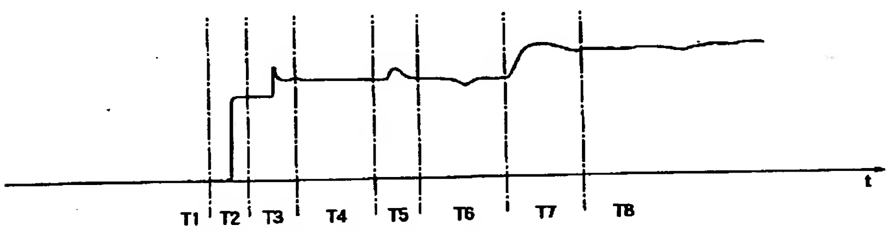
【図３】



【図４】



【図５】



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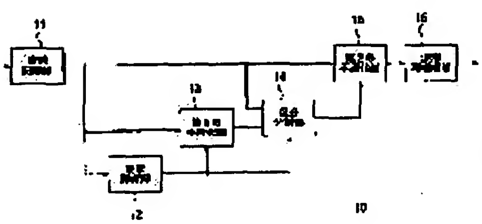
SHIBATA KEIICHI

TAMURA NAOHISA

(54) DEVICE AND METHOD FOR SIGNAL PROCESSING



sing device capable of adequately and automatically
gnal waveform data.
putted to a signal processing device 10 is stored in a
'requency component is abstracted from the signal
:tion 12. When a power of the high frequency component
d value, a smoothing operation is applied to a whole part
thing section 13. In a partition division section 14, when
;inal waveform is selected and when the smoothing is
he smoothing is selected, then the changed condition of
l the original waveform is divided into a plurality of
applied to each of the partitions by a second smoothing
: of the partitions subjected to the smoothing are
ɡ section 16 to restructure the waveform obtained by

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[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3108317
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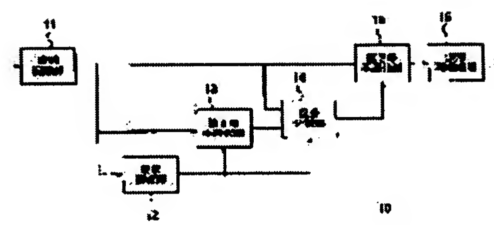
(54) DEVICE AND METHOD FOR SIGNAL PROCESSING

(57)Abstract:
PURPOSE: To provide a signal processing device capable of adequately and automatically executing a smoothing operation for signal waveform data.



CONSTITUTION: A signal waveform inputted to a signal processing device 10 is stored in a waveform memory section 11. A high frequency component is abstracted from the signal waveform by a waveform analyzing section 12. When a power of the high frequency component is equal to or greater than a prescribed value, a smoothing operation is applied to a whole part of the signal waveform by a first smoothing section 13. In a partition division section 14, when the smoothing is not executed the original waveform is selected and when the smoothing is executed the waveform subjected to the smoothing is selected, then the changed condition of the selected waveform is analyzed and the original waveform is divided into a plurality of partitions. The smoothing operation is applied to each of the partitions by a second smoothing section 15. All of the signal waveforms of the partitions subjected to the smoothing are integrated by a waveform restructuring section 16 to restructure the waveform obtained by smoothing the original

waveform.

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CLAIMS

[Claim(s)]
[Claim 1] The signal processor characterized by providing the following. A division means to carry out frequency analysis, and for power to remove the noise component of a big high frequency component, and to divide the time series data point of the agency describing above for every continuous field based on the lenience and severity of the aforementioned change about the large time series data point of the lenience-and-severity difference of change. A smoothing means to smooth the time series data point for every field by which division was carried out [aforementioned]. A wave reconstruction means to make the time series data point for every field by which smoothing was carried out [aforementioned] correspond to the original time series data point, and to reconfigurate it.
[Claim 2] The aforementioned smoothing means is a signal processor according to claim 1 which smooths the time series data point for every field by which division was carried out [aforementioned] by the spline smoothing method.
[Claim 3] The aforementioned division means is a signal processor according to claim 1 or 2 which has a dividing point determination means to divide into the intense field of change, and the loose field of change an analysis means to carry out frequency analysis of the aforementioned time series data point by the Fourier transform, and to detect the noise of a high frequency component, a low pass filter means by which the power of the high frequency component by which detection was carried out [aforementioned] removes a large noise component, and the time series data point from which the aforementioned noise component was removed.
[Claim 4] When frequency analysis is carried out about the large time series data point of the lenience-and-severity difference of change and the noise of a high frequency component with big power is detected by the aforementioned analysis Remove this noise component and the time series data point of the agency describing above is divided for every continuous field based on the lenience and severity of the aforementioned change. The signal-processing method which smooths the time series data point for every field by which division was carried out [aforementioned], and the time series data point for every field by which smoothing was carried out [aforementioned] is made to correspond to the original time series data point, and reconfigurates it.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the signal processor and the signal-processing method of performing the noise rejection and smoothing of a signal wave form which were observed.
[0002]
[Description of the Prior Art] For example, a predetermined pulse signal is impressed to an electric wire for the abnormalities and failure which the electric wire disconnected, or was [failure] covered with water and produced, when observing and inspecting the reflective signal, as a method of removing and smoothing the noise of the observed data point, a Fourier analysis detects a RF noise and the way a predetermined filter removes the RF noise is often used. However, it is not suitable for the wave of a method [such] tending to become blunt generally, and maintaining the position of a changing point.
[0003] As a method of preserving and smoothing the feature which a wave has, the spline smoothing technique is suitable. however -- when the case where a noise is large, and the intense part of change continue also in spline smoothing, or case the difference of the intense place of change and a flat place is intense -- a wave -- becoming blunt -- it was not avoided Then, when [with especially an important wave] a wave performs various observation until now, choosing a parameter, the number of joints, etc. suitably, the operator who has mathematical knowledge, such as the Fourier transform and a spline function, to some extent applies a trial-and-error method, performs noise rejection, and is made to perform suitable smoothing.
[0004]
[Problem(s) to be Solved by the Invention] However, since the way trial and error perform smoothing while choosing a parameter suitably such needed functions, such as the Fourier transform, and the know how on information processing to some extent, it was not that only the operator who understands the method of smoothing can carry out but anyone can do. Therefore, even if who used, when even the finger example carried out the system by which a suitable smooth result is obtained, i.e., measurement data, selection and trial and error of each technique were performed automatically, and the request to the wave smoothing equipment which outputs the wave after smooth was.
[0005] Therefore, the purpose of this invention is to offer the signal processor which can perform appropriately and automatically processing of the noise rejection and smoothing to the observed signal wave form data. Moreover, other purposes of this invention are to offer the signal-processing method that data smoothing to the observed signal wave form data can be performed appropriately.
[0006]
[Means for Solving the Problem] In order to solve the aforementioned technical problem, when the state of a wave-like change was uniform-like, paying attention to the ability to perform smoothing appropriately, for example by the spline smoothing method, for every same part [the state of change of the observed signal wave form data], a suitable parameter is set up respectively and it was made to perform smoothing.
[0007] therefore, the signal processor of this invention about the large time series data point of the

lenience-and-severity difference of change A division means to carry out frequency analysis, and for power to remove the noise component of a big high frequency component, and to divide the time series data point of the agency describing above for every continuous field based on the lenience and severity of the aforementioned change, It has a smoothing means to smooth the time series data point for every field by which division was carried out [aforementioned], and a wave reconstruction means to make the time series data point for every field by which smoothing was carried out [aforementioned] correspond to the original time series data point, and to reconfigurate it.

[0008] Specifically, the aforementioned smoothing means smooths the time series data point for every field by which division was carried out [aforementioned] by the spline smoothing method.

[0009] It has a dividing point determination means to divide into the intense field of change, and the loose field of change an analysis means for the aforementioned division means to carry out frequency analysis of the aforementioned time series data point by the Fourier transform suitably, and to detect the noise of a high frequency component, a low pass filter means by which the power of the high frequency component by which detection was carried out [aforementioned] removes a large noise component, and the time series data point from which the aforementioned noise component was removed.

[0010] Moreover, frequency analysis of the signal-processing method of this invention is carried out about the large time series data point of the lenience-and-severity difference of change. When the noise of a high frequency component with big power is detected by the aforementioned analysis Remove this noise component and the time series data point of the agency describing above is divided for every continuous field based on the lenience and severity of the aforementioned change. The time series data point for every field by which division was carried out [aforementioned] is smoothed, and the time series data point for every field by which smoothing was carried out [aforementioned] is made to correspond to the original time series data point, and is reconfigurated.

[0011]

[Function] According to the signal processor of this invention, in a division means, frequency analysis is carried out about the large time series data point of the lenience-and-severity difference of change, and a RF noise is detected. When the RF noise is large power, the dividing point for dividing into the same field [the state of change] for the data point which removed the noise component in the aforementioned division means further, and removed the noise component is searched for. When the power of the aforementioned RF noise is not large, the aforementioned dividing point is searched for for the original time series data point. And the original time series data point is divided into two or more fields based on the dividing point. And the time series data point for every field in which performed smoothing for every field and smoothing was carried out [aforementioned] by the wave reconstruction means each divided by the smoothing means is made to correspond to the original time series data point, and is reconfigurated.

[0012] Moreover, according to the signal-processing method of this invention, the dividing point for dividing into the same field [the state of change] for the data point which carried out frequency analysis of the large time series data point of the lenience-and-severity difference of change, detected the RF noise, removed the noise component further when the RF noise was large power, and removed the noise component is searched for. When the power of the aforementioned RF noise is not large, the aforementioned dividing point is searched for for the original time series data point. Next, based on the dividing point, the original time series data point is divided into two or more fields, and the each divided time series data point for every field by which smoothing was carried out by performing smoothing for every field is made to correspond to the original time series data point, and is reconfigurated.

[0013]

[Example] One example of this invention is explained with reference to drawing 1 - drawing 5 . Drawing 1 is the block diagram showing the composition of one example of the signal processor of this invention which applied the signal-processing method of this invention. The signal processor 10 of this example has the wave storage section 11, the waveform analysis section 12, the 1st smoothing section 13, the partition division section 14, the 2nd smoothing section 15, and the wave reconstruction section 16. The signal processor 10 of this example is a signal processor for impressing a predetermined pulse

signal to an electric conduction line, when failure of an electric conduction line, for example, an electric conduction line, is covered with water, being used for the test equipment which observes the reflective signal and inspects a conductive state, and smoothing the observed reflective signal.
[0014] First, the composition and operation of each part of a signal processor 10 are explained. The wave storage section 11 memorizes the inputted signal wave form. The HARASHIN number wave memorized by the wave storage section 11 is read from the waveform analysis section 12, the 1st smoothing section 13, the partition division section 14, and the 2nd smoothing section 15.
[0015] The waveform analysis section 12 investigates whether the noise of large power is in the HARASHIN number wave memorized by the wave storage section 11. In the waveform analysis section 12, the fast Fourier transform (FFT) of the HARASHIN number wave is carried out, and it asks for the power distribution according to frequency band, and judges whether the power beyond the predetermined value beforehand set to the predetermined high-frequency field exists. When the power beyond the aforementioned predetermined value exists, the signal which shows that is outputted to the 1st smoothing section 13 and partition division section 14.
[0016] The 1st smoothing section 13 removes the RF noise, when the RF noise of large power is in the HARASHIN number wave. That is, when the signal of a purport with which the noise beyond a predetermined value exists in an input HARASHIN number from the waveform analysis section 12 is inputted, noise rejection is processed to the HARASHIN number wave memorized by the wave storage section 11. The method of this noise rejection is good by the method of the arbitrary usual noise rejection of having used the low pass filter etc. Moreover, you may perform spline smoothing performed in the 2nd smoothing section 15 mentioned later. However, the upper limit of the number of joints is set up within the limits of 5% - 10% of the number of data points in that case. The smooth value calculated about each data point, i.e., the signal wave form by which smoothing was carried out, is outputted to the partition division section 14.
[0017] The partition division section 14 divides a signal wave form into the partition which a sudden change follows, and the partition of a loose change. Specifically, it asks for the differential coefficient of a signal wave form, a thing with the large absolute value is extracted, and it classifies into the loose part (flat part) of change of a signal wave form, and the intense part (change section) of change based on the distribution. Moreover, especially in the change section, it divides so that change of a big wave may be included in each one partition.
[0018] In addition, in the partition division section 14, when the signal of a purport with which the noise beyond a predetermined value exists in an input HARASHIN number from the waveform analysis section 12 is inputted, partition division is processed using the signal wave form with which smoothing was performed in the 1st smoothing section 13 to the input HARASHIN number. Moreover, when the noise beyond a predetermined value does not exist in an input HARASHIN number with the signal inputted from the waveform analysis section 12, partition division is processed for the input HARASHIN number memorized by the wave storage section 11. The data in which each divided partition is shown are outputted to the 2nd smoothing section 15.
[0019] The 2nd smoothing section 15 processes smoothing for each [which was divided by the partition division section 14 for the input HARASHIN number memorized by the wave storage section 11] partition of every. This smoothing is performed by the smoothing method by the spline function. Hereafter, this smoothing is explained.
[0020] Smoothing by the spline function in this example is performed by asking for m-th B spline smoothing formula which becomes below the allowed value to which the joint of a spline function was added in adaptation, and to which the remainder sum of squares was given. That is, the HARASHIN number data point is the dispersed point x1, x2, ..., xn. It sets and they are observation error sigma1, sigma2, ..., sigman. The observed value y1 which it has, and y2, ..., yn When it is data, Remainder sum-of-squares deltanr2 shown in a formula 1 Allowed value delta t2 It asks for m-th B spline smoothing formula of a formula 2, and the smooth value of each point is calculated based on the smoothing formula so that it may become the following.
[0021]

[Equation 1]

$$\delta_{ni}^{2}=\sum_{i=1}^{n}\frac{1}{\sigma_i^2}\left\{y_i-\bar{S}(xi)\right\}^2 \quad \cdots (1)$$

$$\bar{S}(x)=\sum_{j=-m+1}^{ni-1}C_j N_{j,}m+1(x) \quad \cdots (2)$$

ただし、n はデータ点数、
Nj,m+1 (X)は B スプライン、
m は B スプラインの次数で本実施例では 3、
S (X)は ξ1, ξ2…, ξnr を節点列とする
m 次の B スプライン平滑化式、
Cj は係数
である。

[0022] First, the ends x1 of the section which performs smoothing and xn Remainder sum-of-squares deltanr2 shown in the formula 1 as a joint xi 1 and xinr It is the coefficient cj of the spline smoothing formula of a formula 2 so that it may become the minimum. It determines. This remainder sum-of-squares deltanr2 When the conditions of a formula 3 are fulfilled, it is the coefficient cj. It considers as m-th B spline smoothing formula which should ask for the spline smoothing formula of the formula 2 to depend.
[0023]
[Equation 2]

[0024] It is remainder sum-of-squares deltanr2. When not fulfilling the conditions of a formula 3, it calculates each partial section [xi of a joint train, and the remainder square partial sum in xij+1 about j by the formula 3, and it is [0025].
[Equation 3]

$$\delta^2(j,n_r)=\sum_{\xi_j \le x_i < \xi_{j+1}}\frac{1}{\sigma_i^2}\left\{y_i-\bar{S}(x_i)\right\}^2 \quad \cdots (4)$$

[0026] In it, it adds to a joint train by using as a new joint middle point xi= (xij+xij+1) / 2 of the section where the value of a formula 4 serves as the maximum. Remainder sum-of-squares deltanr2 which rearranged the updated joint train into small order, and showed it in the formula 1 as the new joint train xi 1, xi 2, ..., xinr, and xinr+1 It is the coefficient cj of the spline smoothing formula of a formula 2 so that it may become the minimum. It determines and the same processing as the following is repeated. In addition, within the upper limit defined beforehand, the number of a joint shall be increased one by one and taken as about 10% - about 30% of range of the number of data points of an input data point in the 1st smoothing section 13 of a signal processor 10. And if the spline smoothing formula showing in a formula 2 can be found, a smooth value will be calculated about each data point.
[0027] In the 2nd smoothing section 15, the wave reconstruction section 16 doubles suitably the signal by which smoothing was carried out for every partition based on the information by which division was carried out [aforementioned], and reconfigurates a signal wave form.
[0028] Next, operation of a signal processor 10 is explained with reference to drawing 2 . When starting processing, a signal processor 10 memorizes the inputted signal wave form data in the wave storage section 11 first (Step S0). Next, in the waveform analysis section 12, the Fourier analysis of the inputted

signal wave form data is carried out, a high frequency component is extracted, and the power spectrum is computed (Step S1). When it is beyond the predetermined value that the power of the high frequency component defined beforehand, in the 1st smoothing section 13, smoothing is performed to the inputted whole signal wave form data which is memorized by (Step S2) and the wave storage section 11 (Step S3).

[0029] And when the power of a high frequency component is below a predetermined value in Step S2, the boundary of the section where the states of change by the signal wave form differ [for the HARASHIN number data point,] in the partition division section 14 for the signal wave form data with which smoothing was given at Step S3 when the power of a high frequency component is beyond a predetermined value is extracted as a dividing point (step S4). And the inputted HARASHIN number data point is divided into two or more partitions according to the dividing point (Step S5), and smoothing is processed for every partition in the 2nd smoothing section 15 (Step S6). If processing of smoothing is completed about a part for the whole division (Step S7), the signal wave form with which smoothing was carried out for every partition in the wave reconstruction section 16 will be unified, a wave is reconfigurated (Step S8), the smoothed signal wave form will be obtained and processing will be ended (step S9).

[0030] Next, the example of the signal by which smoothing was carried out with the signal processor 10 is illustrated to drawing 3 - drawing 5 . Drawing 3 is drawing showing the example of an input signal data point, and is drawing showing the wave in which the noise of a RF has been. In the 1st smoothing section 13, the RF noise which has been in the whole data point is first removed to such signal wave form data. The signal wave form of the result is shown in drawing 4 .

[0031] It will be divided into the partitions T1-T8 shown in drawing 4 if it divides into the intense change section of change, and a flat part with comparatively little change based on the differential coefficient for the signal wave form shown in this drawing 4 . In drawing 4 , partitions T1, T4, T6, and T8 are flat parts, and partitions T2, T3, T5, and T7 are the change sections. It is divided into the separate partition although the partition T2 and the partition T3 adjoin in order to divide so that one intense part of change of a signal wave form may be included in each partition of the change section as mentioned above. And the signal wave form by which smoothing was carried out as shown in drawing 5 is obtained by performing smoothing for each [which was shown in drawing 4] partition of every.

[0032] As explained above, in the signal processor 10 of this example, it deals with partition division beforehand to a wave, and spline smoothing is performed for every partition after that. Therefore, without spoiling the wave-like feature also as the whole signal wave form, since smoothing can be appropriately performed according to the state of the signal wave type of each partition, suitable smoothing could be performed and it is divided. Moreover, **********-izing is possible even when the noise of power considerable when a wave makes only one place especially the intense part of change included in each partition like this example also in the change section which is changing a lot is overlapped.

[0033] in addition, restrict the signal processor and the signal-processing method of this invention to this example -- it is not ** and various alterations are possible For example, the signal processor of this example was a signal processor for impressing a predetermined pulse signal to an electric conduction line, when failure of an electric conduction line, for example, an electric conduction line, is covered with water, being used for the test equipment which observes the reflective signal and inspects a conductive state, and smoothing the observed reflective signal. However, it is applicable to various test equipment which analyzes not the thing restricted to this but a propagation wave, and diagnoses the interior. Moreover, it is applicable to smoothing of the usual communication wave etc.

[0034] Moreover, although it shall smooth using a spline function as the smoothing method, it is not restricted to this and does not interfere at all by the various smoothing methods, for example, a method so that according to wavelet transform.

[0035] Moreover, the use gestalt of the signal processor of this invention may be used with various gestalten. For example, the signal wave form observed may be inputted into the signal processor of a direct this example, smoothing of a signal wave form may be performed by the real time, and a gestalt

which summarizes behind and is analyzed is [a gestalt which outputs immediately the signal wave form by which smoothing was carried out, and is inputted into a latter processor is sufficient, and / the observed signal wave form may be recorded on the recorder etc., and] sufficient. Furthermore, the operation gestalt may be carried out by the hardware of exclusive use, and may be carried out using general-purpose computer equipment.

[0036]

[Effect of the Invention] By using the signal processor of this invention, smoothing to the observed signal wave form data can be processed appropriately and automatically. Therefore, even if who uses, the system by which a suitable smooth result is obtained can be offered, and the processing of a signal wave form observed also in ordinary operators other than a special operator is attained. As a result, also in the site which inspects an electric wire etc., for example, it is based on the observed signal wave form, and inspection becomes it is efficient and possible. Moreover, according to the signal-processing method of this invention, an operator does not need to repeat trial and error and can perform automatically processing of smoothing to the observed signal wave form data appropriately.

[Translation done.]

PATENT ABSTRACTS OF JAPAN

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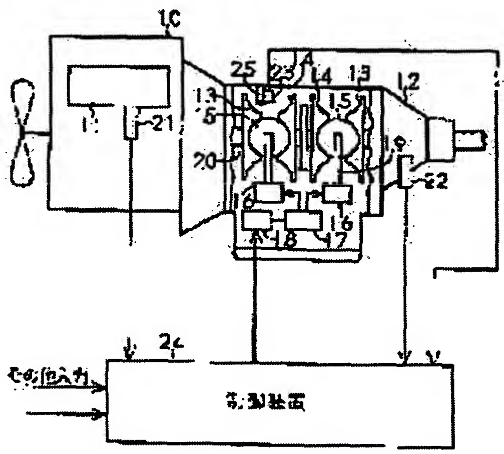
(71)Applicant : JATCO CORP
(72)Inventor : OKAZAKI MAKOTO

(54) CONTROL DEVICE OF CONTINUOUSLY VARIABLE TRANSMISSION OF TROIDAL TYPE

(57)Abstract:

PROBLEM TO BE SOLVED: To secure a normal torque transmitted condition with a traction transmission using friction rollers between an input disc and an output disc over a wide temp. range from a low to a high temp. level.



SOLUTION: The oil temp. immediately before being supplied to an input disc 13 and an output disc 14 is sensed by an oil temp. sensor 23. The strength of an oil film lowers with rising temp., and a control device 24 sets large the service extent of the inclining angle of a friction roller 15 in the range the oil temp. is low and narrows the service extent of the roller inclining angle when the oil temp. heightens so as to secure large the rotational radius of the roller contacting point on the input disc 13 and the output disc 14. This allows ensuring a high acceleration performance at a low speed and a low rate of fuel consumption at a high speed and avoids surface roughening of the discs 13 and 14 caused by rupture of the oil film.

LEGAL STATUS

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[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The change gear ratio of the toroidal formula nonstep variable speed gear with which the friction roller which can adjust the degree of angle of inclination between the input disk which made the oil film form and counter a toroidal side, and an output disk bears power transfer In the control unit of the toroidal formula nonstep variable speed gear controlled according to the throttle opening and the vehicle speed of **** The control unit of the toroidal formula nonstep variable speed gear characterized by establishing a judgment means to judge the temperature of the aforementioned oil film, and a setting means to set up at least one side of the upper limit of the aforementioned degree of angle of inclination, and a minimum based on the judged temperature of the aforementioned oil film, and controlling the aforementioned change gear ratio within the limits of the set-up aforementioned degree of angle of inclination.
[Claim 2] The aforementioned judgment means is the control unit of the toroidal formula nonstep variable speed gear according to claim 1 characterized by judging the temperature of the aforementioned oil film based on the temperature of oil just before the toroidal side of the aforementioned input disk and an output disk is supplied.
[Claim 3] It is the control unit of the toroidal formula nonstep variable speed gear according to claim 1 or 2 which the upper limit of the aforementioned degree of angle of inclination will be characterized predetermined width-of-face reduction, and will be characterized for a minimum by predetermined width-of-face raising ****** if the aforementioned setting means keeps constant the upper limit and minimum of the aforementioned degree of angle of inclination in the range with the judged low temperature of the aforementioned oil film and the temperature of the aforementioned oil film exceeds a predetermined threshold.

[Translation done.]

PRIOR ART

[Description of the Prior Art] For example, a predetermined pulse signal is impressed to an electric wire for the abnormalities and failure which the electric wire disconnected, or was [failure] covered with water and produced, when observing and inspecting the reflective signal, as a method of removing and smoothing the noise of the observed data point, a Fourier analysis detects a RF noise and the way a predetermined filter removes the RF noise is often used. However, it is not suitable for the wave of a method [such] tending to become blunt generally, and maintaining the position of a changing point.
[0003] As a method of preserving and smoothing the feature which a wave has, the spline smoothing technique is suitable. however -- when the case where a noise is large, and the intense part of change continue also in spline smoothing, or case the difference of the intense place of change and a flat place is intense -- a wave -- becoming blunt -- it was not avoided Then, when [with especially an important wave] a wave performs various observation until now, choosing a parameter, the number of joints, etc. suitably, the operator who has mathematical knowledge, such as the Fourier transform and a spline function, to some extent applies a trial-and-error method, performs noise rejection, and is made to perform suitable smoothing.

[Translation done.]

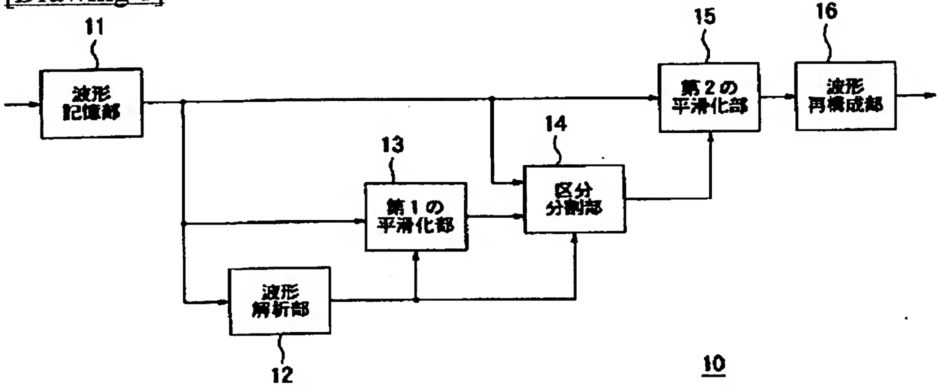
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the composition of the signal processor of one example of this invention.
[Drawing 2] It is the flow chart which shows operation of the signal processor of one example of this invention.
[Drawing 3] It is drawing showing the signal wave form data inputted into the signal processor of this invention.
[Drawing 4] It is drawing showing the state where removed the RF noise to the signal wave form data shown in drawing 3 , and it divided into the partition.
[Drawing 5] It is drawing showing the signal wave form data of the result which gave smoothing with the signal processor of this invention to the signal wave form data shown in drawing 3 .
[Description of Notations]
10 -- Signal processor
11 -- Wave storage section
12 -- Waveform analysis section
13 -- The 1st smoothing section
14 -- Partition division section
15 -- The 2nd smoothing section
16 -- Wave reconstruction section

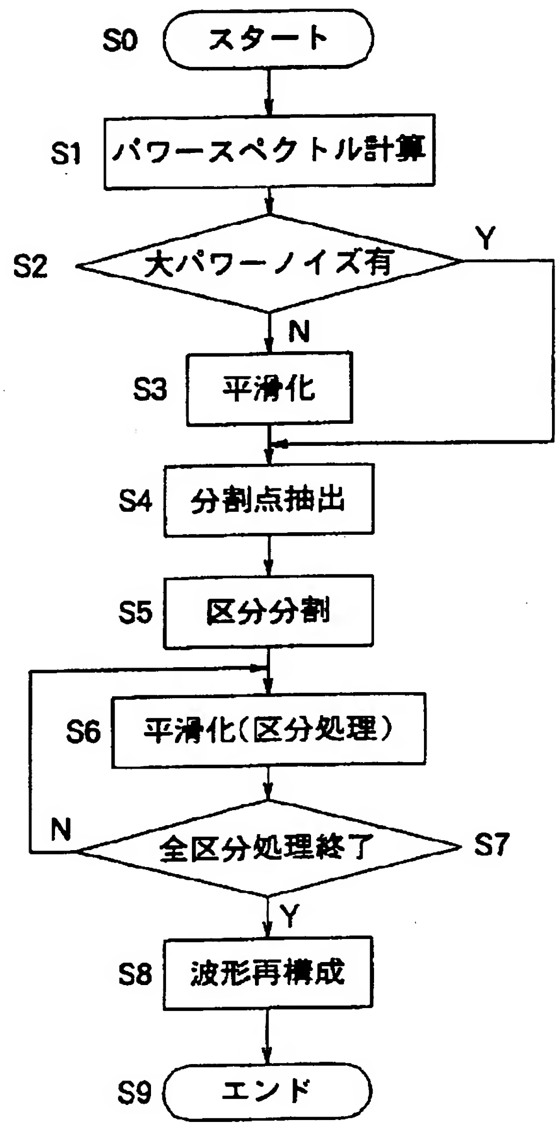
[Translation done.]

DRAWINGS

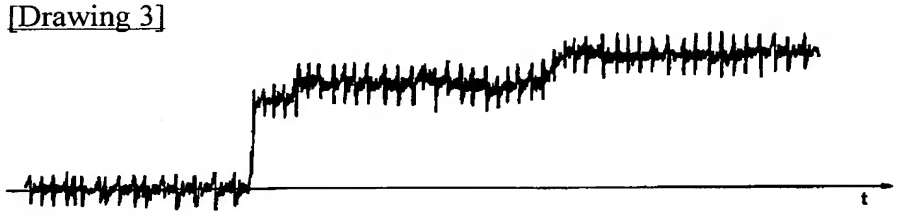
[Drawing 1]



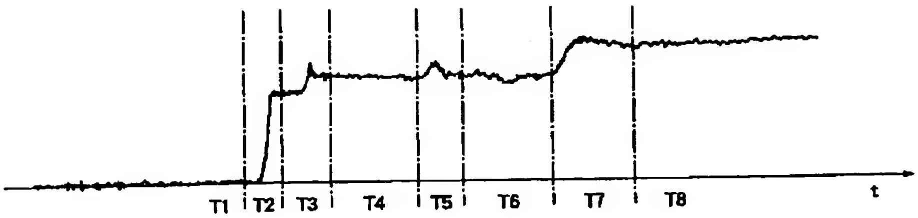
[Drawing 2]



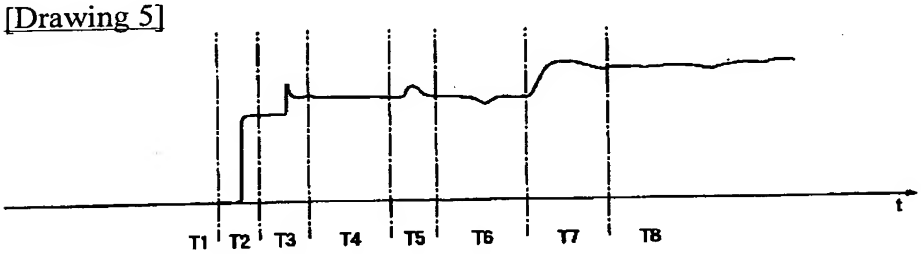
[Drawing 3]



[Drawing 4]



[Drawing 5]



[Translation done.]